

Wake Visualization of a Full-Scale Tiltrotor in Hover

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The objectives of this program were to measure the tip-vortex trajectory of a full-scale, hovering tiltrotor and to compare the vortex trajectory of the baseline rotor with that of the subwing rotor (first figure). The subwing, which is mounted at the blade tip, can split the strong concentrated tip vortex into two weaker vortices, and weakening the vortex can reduce the blade-vortex interaction noise. Two sets of subwings with different incidence angles were tested in this program.

The wake-visualization program was conducted on a right-hand XV-15 tiltrotor in the Ames 80- by 120-Foot Wind Tunnel. A smoke dispenser was installed near the rotor tip and an optics pod was placed below the rotor plane on the wind tunnel floor. When fed with a laser beam via a fiber-optic cable, the pod generated a thin laser sheet and illuminated the entrained smoke in the rotor wake. Images of the rotor-wake geometry were recorded on videotapes and later digitized on a Macintosh for analysis.

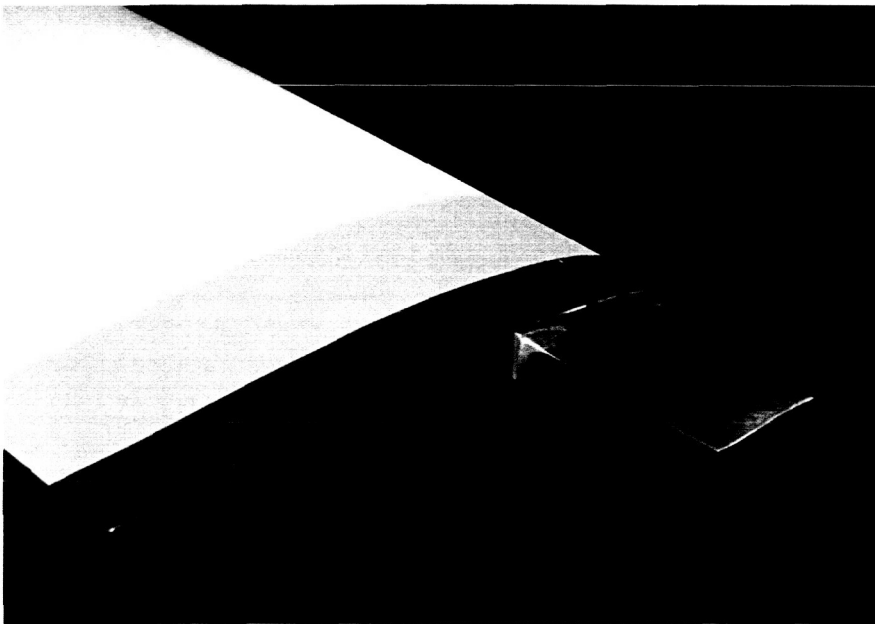


Fig. 1. Subwing blade.

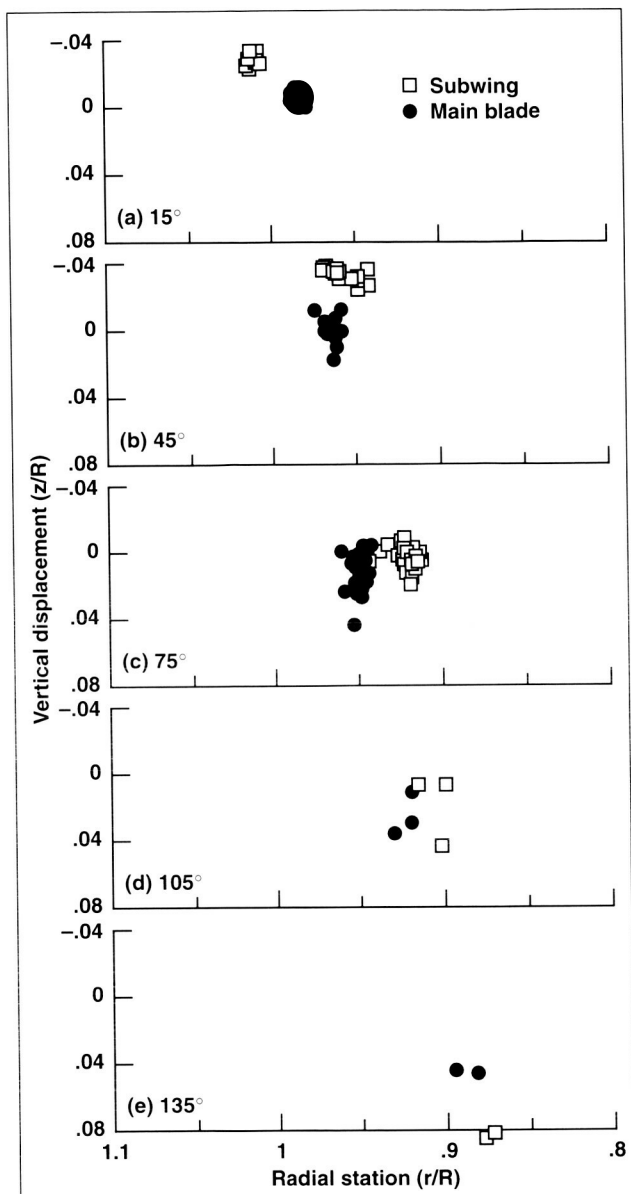


Fig. 2. Interaction of the subwing vortex with the main-blade vortex at different wake ages.

For both subwing rotors, the laser sheet illuminated a vortex pair rotating in the same direction. The trailing vortex generated by the subwing appears to be weaker than that of the main blade. Initially the subwing wake contracts faster than the main-blade wake. As the vortex pair is convected downstream, the two vortices rotate, relative to each other, approximately half a revolution in a 75-degree blade rotation (second figure). Subsequently, the vortex pair combine into a single vortex at a wake age between 150 degrees and 165 degrees. The trajectory of the combined vortex has the same trajectory as the baseline rotor. A small improvement in hover performance over that of the baseline rotor is observed for both subwing rotors.

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